Welcome to the Strategic Plan 2016 – 2021 of the University of Liverpool's Institute of Infection and Global Health. In this document we describe our current and future ambition, and how we intend to achieve it.

In developing this Strategic Plan, we have examined our strengths, and identified the global challenges that our work seeks to address. These challenges – relating to the growing needs to predict, diagnose, treat and prevent infectious diseases in animals and humans – are both real and big: they threaten the livelihood and welfare of people globally, as they affect the security and safety of our food supply or contribute to the spread of preventable or curable illnesses. The aim of our Institute is to make a material contribution to enhancing lives by tackling these infectious diseases.

Our goals are ambitious, yet we believe they are achievable. Doing so will require the best scientific talent available. We will need to grow our team, nurture the next generation of researchers, and collaborate with others. We will also need to hold ourselves accountable to the objectives we are setting. We are looking forward to receiving your feedback on the plans outlined in this document.

Thank you for your support of our work.
Infectious diseases impose a huge burden on human and animal health. The World Health Organization reports that three of the ten leading causes of death of people in 2012 were infectious diseases, responsible for more than 6 million deaths worldwide.

Infectious diseases occur globally, but their impact is greatest in the developing world where five of the ten leading causes of death are infections. The global burden of infectious diseases of animals, including livestock, has not been quantified, but is undoubtedly high. Such diseases are important because they affect animal welfare; they have negative impacts on local, regional and national incomes; and they are a source of human disease. The University of Liverpool is recognised as an international leader in infection and global health, as reaffirmed in the UK Government’s Research Excellence Framework (REF 2014).

Mission
Our mission is to be an international centre of excellence dedicated to improving the health of humans and animals by tackling key infectious diseases in the UK and globally. The Institute, established in 2010, brings together leading medical, veterinary, and basic science infectious disease researchers from across the University. We conduct cutting edge research on the transmission, diagnosis, treatment and prevention of infectious diseases, and are training the next generation of researchers. We recognise that the health of humans, animals and the environment are linked, and we tackle infections at the human-animal interface, putting us at the forefront of the One Health agenda.

We integrate fundamental biology, veterinary, medical, population and social sciences research in an inter-disciplinary manner. We work with regional, national and international partners to advance the control of infectious diseases and improve health, by influencing national and international policy.

Understanding how pathogens cause disease:
We are studying the interactions between pathogens and their hosts by investigating the key molecular, cellular and immunological processes in health and disease.

Pioneering diagnostics, treatments and vaccines:
We are working on better diagnostic strategies, therapeutics and vaccines, for gastrointestinal, respiratory, neurological and blood infections of humans, as well as addressing drug resistance in viruses, bacteria and parasites which is common to both humans and animals.

Enhancing food safety and security:
We are protecting people from food-borne infections such as Campylobacter and Salmonella as well as ensuring improved control of endemic infectious diseases of food-producing animals to promote their health and welfare.

Tracking emerging and zoonotic infections:
We are studying insect-borne diseases and those that spread from animals to humans, as well as the effect of climate change, environmental and societal impacts on diseases burden.

Improving the health of pets, working animals and their owners:
We are carrying out research and surveillance of diseases in cats, dogs and horses, and studying how animal ownership can impact on human health.

Mission of the Institute of Infection and Global Health (IGH) at the University of Liverpool

Our research is organised into three departments: the Department of Infection Biology considers infection at the molecular and cellular level, the Department of Clinical Infection, Microbiology and Immunology examines infection in individuals, and the Department of Epidemiology and Population Health studies infection at the population level. Our five major research themes bring together scientists from across the departments.

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Our mission is to improve the health of humans and animals by tackling key infectious diseases locally and globally.

Institute of Infection and Global Health (IGH)

WE HOST TWO EXTERNALLY FUNDED NATIONAL CENTRES OF EXCELLENCE:

The National Institute for Health Research (NIHR) Health Protection Research Unit in Emerging and Zoonotic Infections
The National Institute for Health Research (NIHR) Health Protection Research Unit in Gastrointestinal Infections

In addition, we are partners in the Health e-Research Centre, part of the Farr Institute of Health Informatics Research.
Strategic Review

In 2015 the strengths of IGH were reviewed in the context of a number of globally important research challenges. This led to the selection of five major challenges: these will become an increasing focus of IGH’s research over the next five years. A summary is below; and details of each challenge and IGH’s strategy for addressing them are provided on the following pages.

**MAJOR CHALLENGES**

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Description</th>
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<tbody>
<tr>
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<td>Rapid climatic, environmental and societal changes are leading to the emergence of new diseases and the spread of existing ones.</td>
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<td><strong>FOOD SECURITY</strong></td>
<td>1 in 10 people globally lack sufficient food for a healthy, active life. Feeding current and future populations requires a secure and safe supply of food.</td>
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<td><strong>ANTIMICROBIAL RESISTANCE</strong></td>
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<td>Vaccines are the single most effective method to reduce the burden of infectious diseases in humans and animals, but many major diseases lack effective vaccines for their control.</td>
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**IMPACT – WITHIN 5 YEARS WE WILL HAVE**

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**Case Study**

**Challenge one: Environmental change**

Rapid, climatic, environmental and societal changes are leading to the emergence of new diseases and the spread of existing ones.

**The challenge**

Changes in the climate, environment, and society help to drive the emergence and spread of infectious diseases. About half of all infectious diseases of humans and animals are sensitive to climate, and many of them are expected to be affected by climate change. This is particularly the case for diseases spread by insect vectors, which cause the deaths of nearly 750,000 people in 2012, as well as a huge burden of mortality and productivity loss in food-producing animals. Climate change will also impact on the burden of water-borne and food-borne diseases. Other global changes, such as urbanisation, changing land use and increased travel and trade will drive the emergence of new diseases and the spread of existing ones. The devastating Ebola virus disease epidemic in West Africa in 2014/15 underscored the impact of emerging and re-emerging infections.

**Our contribution**

IGH will develop methods to understand and predict the effects of climate, environmental and societal change on the emergence and spread of infectious diseases of humans and animals, so that measures to mitigate or adapt to consequences of global change can be developed. For example, IGH will develop models for the transmission and spread of an animal disease, bluetongue, under future conditions of climate and environment. We will investigate how the structure of human societies and the contacts between people affect the spread of respiratory diseases like influenza, and the role of urbanisation in the emergence of pathogens in developing countries. We will identify which types of native UK mosquitos are able to spread viral infections to people and animals, should the pathogens emerge here in the future. We will study how tick species are affected by temperature and rainfall so that we can develop systems for forecasting people’s risk of exposure to Lyme disease, an emerging disease in the UK. We will work closely with relevant policy-makers, for example with Public Health England, in collaboration with the UK and US Forests and Wildlife Service and with the World Health Organization and national governments.

**Strategy**

IGH will provide evidence to help predict and mitigate the impacts of climate, environmental, and societal changes on human and animal health. We will develop systems for examining transmission of emerging animal diseases through insect and tick vectors. This will include Hazard Group Three pathogens, and in collaboration with Public Health England, Hazard Group 4 pathogens. We will strengthen our work in UK and international public health with the appointment of further personnel in veterinary, and health protection.

**Case Study**

Challenge Two Food security

1 in 10 people globally lack sufficient food for a healthy, active life. Feeding current and future populations requires a secure and safe supply of food.

The challenge

Nearly 10% of people today, mostly in the developing world, lack a diet that is nutritionally adequate to maintain active lives. In particular, women and children suffer most. The global population is expected to rise further, to 9 billion, by 2050. To feed current and future populations we need to ensure a secure food supply that is safe to eat. Food production in future is expected to be challenged by the effects of climate change on crops, animals and driving the emergence and spread of infectious diseases. A further challenge is the spread of resistant organisms in a formal sense – resistance to the treatments used against viruses, bacteria, fungi and parasites.

Our contribution

IGH will contribute to the prevention and control of infectious disease in food producing animals, by improving diagnostics, disease surveillance and the development of control measures to reduce the likelihood of livestock and wildlife contributing to the spread of zoonotic bacterial and parasitic pathogens in animal populations. We will seek to develop key resources at our Leahurst veterinary campus, particularly large animal and poultry facilities, and to strengthen critical mass with further investment in these areas. We will develop the area of co-infection with regard to zoonotic diseases. We will develop rapid, accurate and pen-side diagnostics. We will also need to better understand what contribution we can promote sustainable behaviour change towards prudent use of antimicrobials and to provide realistic and clinically relevant evidence-based treatment therapies, to reduce the usage of current antimicrobial treatment strategies. We will develop key resources at our Leahurst veterinary campus, particularly large animal and poultry facilities, and to strengthen critical mass with further investment in these areas. We will develop the area of co-infection with regard to zoonotic diseases. We will develop rapid, accurate and pen-side diagnostics. We will also need to better understand what contribution we can promote sustainable behaviour change towards prudent use of antimicrobials and to provide realistic and clinically relevant evidence-based treatment therapies, to reduce the usage of current antimicrobial treatment strategies.

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Challenge Three Antimicrobial resistance

Microbes are gaining resistance to the treatments used to control them, making antimicrobial resistance (AMR) one of the greatest current threats to human and animal health.

The challenge

Antimicrobial resistance is recognised by the World Health Organization as one of the greatest threats to human and animal health, and is expected to cause 10 million deaths per year by 2050. The development of resistance to antimicrobial treatments is the result of overuse and misuse of antimicrobials in a given population. The development of resistance is faster in some kinds of bacteria, such as some strains of Staphylococcus aureus (MRSA) and Staphylococcus epidermidis, than in others. We have shown that specifically engineered liposomes can neutralise cytolytic bacterial toxins and reduce cell death in vitro. We have shown that specifically engineered liposomes can neutralise cytolytic bacterial toxins and reduce cell death in vitro. We have shown that specifically engineered liposomes can neutralise cytolytic bacterial toxins and reduce cell death in vitro. We have shown that specifically engineered liposomes can neutralise cytolytic bacterial toxins and reduce cell death in vitro. Neospora caninum is the leading cause of abortion in cattle in the UK, with no effective drugs at present. Antimicrobial resistance to the current arsenal of treatments for Neospora is high. We have shown that using mathematical modelling we can predict when and transmission of the parasite, to show when and why antimicrobials are used in animals and humans, so that we can promote sustainable behaviour change towards prudent use of antimicrobials.

Our contribution

IGH will develop novel therapies against antimicrobial resistance, focusing on augmentation of host immunity, inhibition of pathogen-specific effector functions and phage-based treatment therapies, to reduce the usage of current antimicrobials and to develop new novel antimicrobial strategies.

Strategy

IGH will develop the clinical and environmental factors that drive the emergence and development of AMR, and develop novel antimicrobial treatment strategies.

We will continue to work closely with stakeholders, including Public Health England (PHE), AFBI and the Food Standards Agency, and collaboration on our close links with the relevant NIHR Health Protection Research Units. We will also strengthen our links with social and behavioural scientists, both within and outside Liverpool, to develop our work on proscribing practice behaviour and the ecological and evolutionary trends.
Many people and animals remain untreated for infectious diseases because of a lack of accurate, affordable and available diagnostic tests.

-case study-

Our diagnostic approaches need to be more closely aligned with antimicrobial therapy, including the “start smart, then focus” approach, as advocated by the Chief Medical Officer. Molecular diagnostic approaches need to be more closely aligned with epidemiological data, particularly for diseases-outbreaks, to allow rapid intervention and reduce pathogen transmission.

**Case Study**

**Diagnostic tests**

For many important infections of animals and humans, both in industrialised and tropical settings, there are no vaccines. Where vaccines do exist, to maximise their power and effectiveness, we need to better understand the infection between pathogens and their hosts: the epidemiology and disease burden of such infections, to develop new vaccine candidates, and to evaluate their introduction and effective delivery into populations.

Our contribution

We will develop improved and new diagnostic tests for the major human infection syndromes, including sepsis, respiratory, gastrointestinal and zoonotic infections. We will achieve this by building on our existing national and international network of clinical cohorts, for example the Brain Infections UK network. Through our ZELS Zooline programme based in Kenya, we have already manufactured, with a commercial partner, a lateral flow assay for human and porcine coccidiosis. We will build on this to develop multiplexed bead-based immune-assays over the next few years. We will also examine the behavioural and societal factors that drive the use and misuse of diagnostic tests, so that we can ensure their better utilisation in the future. We will apply a combination of improved diagnostic approaches, including targeted next generation sequencing, to understand the host, pathogen and environmental interactions that drive disease outcomes.

Vaccines are the single most effective method to reduce the burden of infectious diseases in humans and animals. Group A streptococcus includes childhood infections, and the eradication through vaccination of syphilis, meningococcal and gonorrhoeal is a key public health goal. We will develop vaccines to improve immunity in populations and the use of vaccines available, and develop new and improved vaccines. Vaccine-preventable diseases in humans include systemic infections (Group B Streptococcus, meningococcal), respiratory infections (influenza, Streptococcus pneumoniae, pneumococcal), gastrointestinal infections (rotavirus, norovirus, Salmonella) and neurological infections (meningitis, encephalitis, Japanese encephalitis virus). We will identify novel antigens expressed by these pathogens and their host, the epidemiology and disease burden of such infections, to develop new vaccine candidates, and to evaluate their introduction and effective delivery into populations.

Our contribution

We will develop diagnostic tests for diseases of humans and animals, as well as improving existing diagnostic tests.

The use of smarter, integrated, connected health network systems for diagnosis of infections in humans and animals, for example our Health Innovation Challenge Fund project, fully integrated, real-time detection, diagnosis and control of common zoonoses disease clusters and outbreaks, will help us address other major challenges such as antimicrobial resistance.

We will develop this work, across the full network, and strengthen our in-house commercial diagnostic services (European Veterinary Parasitology Diagnostics and Development) and build international partnerships to enhance the impact of the clinical Veterinary Surveillance Network (CLAVENET), and through our strong network of collaborators in the meat and milk industries, we will improve the diagnosis of animal infections including flocks, and dig data-driven information (BIG) intelligence, that drives the use and misuse of diagnostic tests, so that we can ensure their better utilisation in the future. We will apply a combination of improved diagnostic approaches, including targeted next generation sequencing, to understand the host, pathogen and environmental interactions that drive disease outcomes.

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Developing the next generation of researchers and health practitioners

Education of undergraduate and postgraduate students is an essential part of our Institute. We make key contributions to the undergraduate medical, veterinary and basic science programmes at the University of Liverpool, providing research-led teaching to inspire the best undergraduate students to consider careers in academia. We lead a postdoctoral Masters in Research (MiRes) programme, and will complement this by establishing a taught, externally online, Masters in Science (MSc) Course in Infection and Global Health. We will continue to strengthen our support for postgraduate student numbers, both UK/EU and International.

We will strengthen our support for postdoctoral researchers through our MiRes scheme and, through the establishment of a Postdoctoral Society, ensuring they have representation at the highest levels in the Institute. We will continue to develop our FLIGHT Programme, (Fostering Liverpool Institute. We will continue to develop our representation at the highest levels in the Postdoctoral Society, ensuring they have access to networking opportunities, leadership training and mentorship. We will continue to strengthen our support for postdoctoral students and postdoctoral PLACE, (MRes) programme, and will complement this by establishing a taught, externally online, Masters in Science (MSc) Course in Infection and Global Health. We will continue to strengthen our support for postgraduate student numbers, both UK/EU and International.

We will continue to invest in our core research facilities, providing resources for working with high containment level pathogens, and pathogens enteric for work on the core genomic, proteomics and imaging facilities, part of the University of Liverpool Technology Directorate. We have had considerable capital investment in our Institute, more than £300 million, in applications to Innovate UK (formerly the Technology Strategy Board), building on our links with human applications to Innovate UK (formerly the Technology Strategy Board), building on our links with human stakeholders and end-users of our research.

We will continue to develop our strong local, regional, and national partnerships, particularly with the Liverpool School of Tropical Medicine, and Universities of Lancaster and Manchester through the N8 Northern Universities Initiative. We will continue to work closely with colleagues at the Universities of Oxford and Cambridge, the Sanger Centre, the Roslin Institute, the Pirbright Institute, and the Moredun Research Institute. To enhance our major UK clinical programmes we will continue to collaborate with Liverpool Health Partners, and the North West Coast Academic Health Science Network. We will also strengthen our applied research collaborations in southeast Asia.

We will continue to develop our strong links with the National Institute of Mental Health and Neurosciences (NIMHANS) in India to expand our portfolio of research in India. We will continue to develop our strong local, regional, and national partnerships, particularly with the Liverpool School of Tropical Medicine, and Universities of Lancaster and Manchester through the N8 Northern Universities Initiative. We will continue to work closely with colleagues at the Universities of Oxford and Cambridge, the Sanger Centre, the Roslin Institute, the Pirbright Institute, and the Moredun Research Institute. To enhance our major UK clinical programmes we will continue to collaborate with Liverpool Health Partners, and the North West Coast Academic Health Science Network. We will also strengthen our applied research collaborations in southeast Asia.

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Measuring and Monitoring our Progress

We have set targets for five years ahead, and for the next REF in 2020. Our progress against these targets will be assessed annually at our External Advisory Panel meeting.

### CRITERION

<table>
<thead>
<tr>
<th>Ratio of PGR:Staff</th>
<th>BASELINE (average for 2012/13-2014/15)</th>
<th>TARGET FOR 2020</th>
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<td></td>
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<tr>
<td>% research staff returned</td>
<td>83*</td>
<td>&gt;90</td>
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<td>% 4 STAR publications</td>
<td>30</td>
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*% IGH staff returned to REF. **As assessed by IGH panel.

The Institute of Infection and Global Health is at the forefront of the University’s research and is a major contributor to our outstanding international reputation.

Professor Janet Beer, Vice Chancellor, University of Liverpool
We would like to thank the following people for contributing images to this publication: Raquel Medialdea Carrera (cover image) and Ellen Heinsbroek (page 10).